INTRODUCTION

The Space Acceleration Measurement System (SAMS) is an operational space flight experiment developed by the NASA Lewis Research Center for the NASA Headquarters Office of Life and Microgravity Science and Applications. The primary objective of the SAMS project is an acceleration measurement and recording system that can serve a wide variety of microgravity science and technology experiments. SAMS is designed to measure, condition, and record low-gravity accelerations at as many as three experiment sites simultaneously. Since its inception, SAMS has supported 16 shuttle missions through Mir-4; another SAMS unit is on the Mir Space Station.

HIGHLIGHTS

- Configurations for both an indoor pressurized habitable environment (space shuttle middeck, Space Habilitation module, or Spacelab module) and the space vacuum environment (space shuttle cargo bay)
- Three-axis acceleration sampling directly at experiment locations
- Three remote sensor heads, each located as far as 20 feet from the main unit
- Six low-pass-filter frequency choices between 2.5 and 100 hertz for each head
- Three gigabytes of data stored on hard drives from a typical mission

MIDDECK/SPACELAB CONFIGURATION

The middeck/Spacelab SAMS configuration (fig. 1) was designed for installation in the habitable environments of the space shuttle middeck and the Spacelab module. (Specifications for the two SAMS configurations are listed in table I.)

From the front panel of the main unit, the crew can access the control switches, indicators, and hard drives during the mission. The three remote sensor heads are connected to the main unit by three sensor head cables (see cover). The main unit contains the electronics for control and data processing. The two hard drives (fig. 2) provide unlimited data-recording capacity during a mission.

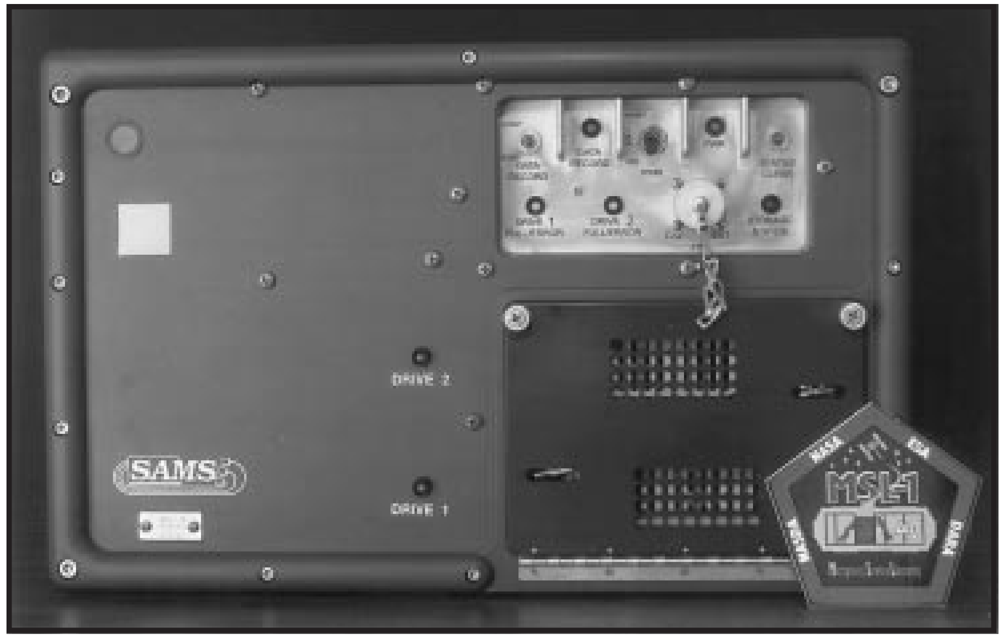

Figure 1.—Space shuttle middeck/Spacelab/space station configuration.

TRIAXIAL SENSOR HEADS

Triaxial sensor heads (TSH's) detect accelerations with three single-axis acceleration sensors. These single-axis sensors use a pendulous proof mass and force-rebalance coils to sense the accelerations. The TSH structure maintains the three single-axis sensors in an orthogonal relationship. Each sensor's output is independently amplified and filtered by a multigain amplifier contained within the sensor head. The sensors have an advertised sensitivity of 1 μg (10^{-6} times normal gravity). They can be mounted on or near an experiment to measure the accelerations experienced by the experiment.

Figure 2.—Middeck/Spacelab/space station configuration with hard drives removed.

COMMANDING AND DOWNLINKING

The outdoor units have historically had the capability for remote commanding from the ground and downlinking of mision data. The indoor units have recently been modified to incorporate this capability. The data are displayed at the NASA Lewis Telescience Support Center or the NASA Marshall Payload Operations Control Center (POCC).

CARGO BAY CONFIGURATION

The cargo bay SAMS configuration (fig. 3) has sealed enclosures for operation in the harsh thermal and vacuum environment of space. This configuration accommodates a control unit containing the electronics for control and data processing and a data storage unit containing four hard drives.

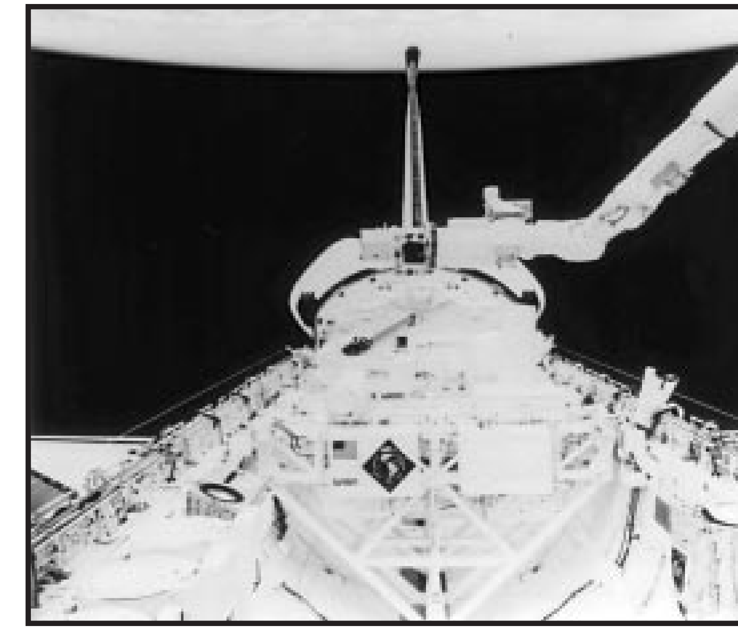

Figure 3.—Cargo bay configuration.

DATA FLOW

In operation the sensors produce signals in response to acceleration inputs. These signals are then amplified, filtered, and converted into digital data, which are stored on hard drives. (See fig. 4 for the SAMS data flow.) The capacity of each hard drive is 2 gigabytes. They are accessible to the crew for space shuttle middeck and Spacelab applications and can be changed during the mission to allow virtually unlimited data-recording capacity. For space shuttle cargo bay applications, in which there is no crew access, the design can accommodate as many as four hard drives for a maximum of 8 gigabytes. Raw data from a SAMS unit mounted in the space shuttle cargo bay may also be downlinked to the POCC for near-real-time data display and analysis. Processed data are provided to interested scientists and investigators after each mission.

Table I.—SAMS SPECIFICATIONS

Characteristic	Configuration		Sensor head
	Middeck/Spacelab	Cargo bay	
Weight, lb	67	200	2.5
Cable length, ft	≤ 20	≤ 20	---
Volume, ft^3	2.1	8.5	[a]75
Power (nominal), W	57	67	---
Sensor type	QA2000	QA2000	---
Data capacity, gigabytes	Unlimited	8.4	---

[a]Cubic inches.

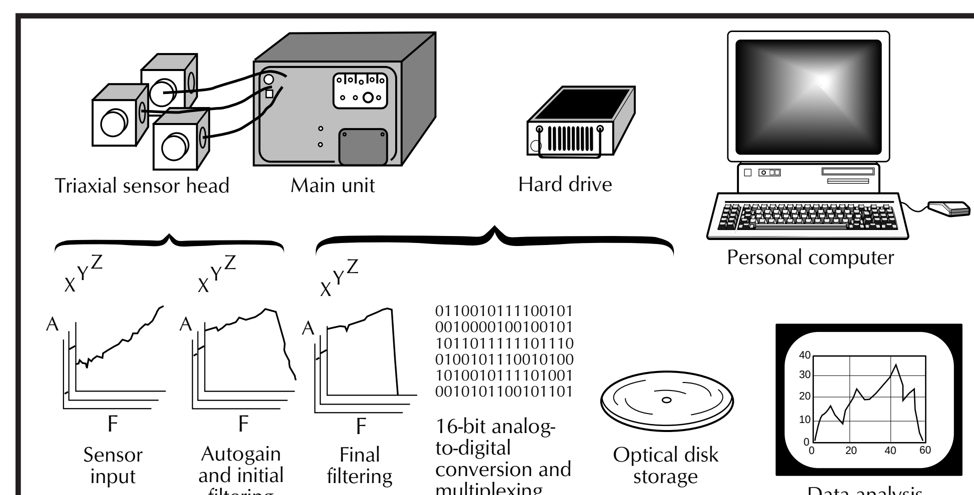

Figure 4.—SAMS data flow.

TECHNICAL DETAILS

Each Sunstrand QA2000 single-axis sensor is a complete, self-contained miniature servomechanism with a resolution and threshold of 1 μg. Each of them is equipped with an internal temperature sensor to allow temperature correction of the data.

As shown in figure 5, three sensors are integrated into a triaxial sensor head (TSH) that also includes the electronics for prefiltering and amplifying the sensor signals. The user can select a gain range of 1, 10, 100, and 1000. Or with the autogain feature, the main unit processor uses the measured data to control gain. Each TSH (maximum of three per SAMS unit) can have a low-pass-filter corner frequency independent of that of the other heads. Each TSH is connected to the main unit by a sensor head cable that may be as long as 20 feet.

A signal-conditioning board contains three six-pole filters, one for each sensor of the TSH.

An analog-to-digital converter board simultaneously samples the three sensor signals from one TSH to minimize phase errors between the three signals. Sampling is done at a rate of five times the filter corner frequency. The board then converts the three sensor signals, the temperature signals, and other peripheral signals to 16-bit digital words.

A primary central processing unit (CPU) board contains an 8188-family microprocessor. This board controls the operation of the entire SAMS unit, including setting the amplifier gains; sampling, buffering, and recording data; and detecting and notifying of faults.

A memory board buffers the data sampled by the analog-to-digital board before they are recorded on the hard drives.

The interrange instrument group (IRIG) decoder board is the interface to the space shuttle timing system; it maintains mission elapsed time for interleaving with the acceleration data stored on the hard drives.

An input/output board is the interface between the control panel and the ground support equipment.

The power supply isolates SAMS from the primary power supplied by the space shuttle and delivers power at various voltages to the rest of the SAMS unit.

The hard drives record data for postmission analysis. They are standard commercial hard drives that have been upgraded for space use.

A second CPU board enables the cargo bay configuration to be used to perform onboard data calculations and provides an interface to experiments, data downlinking, and command uplinking.

Configurations: Two—one for installation in the space shuttle middeck, "Space Hab," or Spacelab and one for the cargo bay

First SAMS mission: First Spacelab Life Sciences mission in mid-1991

Total SAMS missions supported to date: 16 Shuttle missions plus the Mir Space Station

Flight rate: Approximately four SAMS flights per year

Science objective: Measure low-level accelerations at experiment locations on microgravity science missions

Microgravity flights supported:

- International Microgravity Laboratory–1, –2
- Mir Space Station
- United States Microgravity Payload–1, –2, –3, –4
- Spacelab Life Sciences series USML–1, –2, LMS
- Spacelab J
- Middeck microgravity experiments STS–43, –66
- Spacehab–1, –2, –3, Mir–4

SAMS Management

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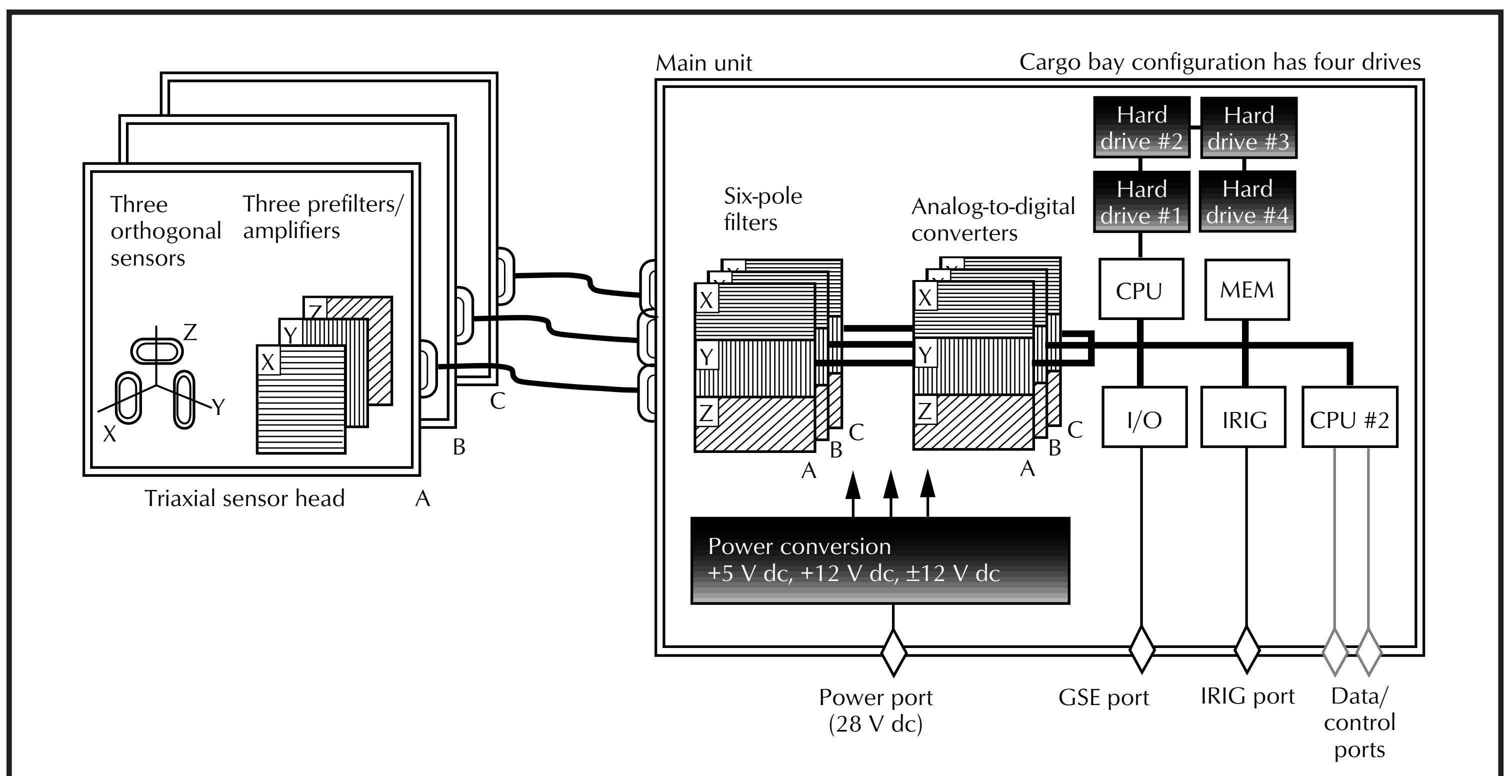

Figure 5.–SAMS block diagram. (Four hard drives denote cargo bay configuration.)

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Space Acceleration Measurement System

Measuring the microgravity environment for space shuttle experiments.

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